First Semester Examination
2020/2021 Academic Session

February 2021

# EAS353 – Reinforced Concrete Structural Design I

Duration : 2 hours

Please check that this examination paper consists of **NINE (9)** pages of printed material including appendix before you begin the examination.

**Instructions :** This paper contains **FIVE (5)** questions. Answer **FOUR (4)** questions.

All questions **MUST BE** answered on a new page.

1. (a). **Figure 1** shows a resultant strain diagram of a concrete section. Determine the depth of the neutral axis (x) to ensure yielding of the tension steel at the ultimate limit state. The maximum compressive strain ($\varepsilon_{cu2}$) in the concrete is taken as 0.0031 for concrete class C55/67. The modulus of elasticity and yield strength of steel is 200 GPa and 500 N/mm$^2$, respectively. The partial factor of safety for steel is 1.15.

[4 marks]

(b). A continuous beam of three equal spans has a constant cross-section that supports a uniformly distributed permanent action including its self-weight of 20 kN/m and a variable action of 15 kN/m. Sketch three possible load arrangements recommended for buildings in accordance with BS EN 1992-1-1:2004+A1:2014. Calculate the load combinations considered for the load arrangement.

[4 marks]

(c). The effective depth and width of a beam are 450 mm and 250 mm, respectively. The yield strength of the steel reinforcement, the compressive strength of concrete, and the concrete cover are 500 N/mm$^2$ and 30 N/mm$^2$, and 30 mm respectively.

(i). Sketch an equivalent rectangular stress block for the cross-section of the beam. Write a bending moment equation about the tension reinforcement of the beam when $\alpha_{cc}$ is equal to 0.9.

[6 marks]

**...3/-**

(ii). EC2 limits the depth of the neutral axis to $x \leq 0.45d$, where $d$ is the effective depth of the beam. The concrete section with the depth of the neutral axis at the specified maximum depth of $0.45d$ is often referred to as the balanced section. Prove that the ultimate moment of resistance of the balanced section equals to $0.167 f_{ck} b d^2$ when $\alpha_{cc}$ is equal to 0.85.

[6 marks]

(d). The effective depth and width of a beam are 310 mm and 150 mm, respectively. The ultimate design moment to be resisted by the section is 180 kNm. Determine the area of tension reinforcement ($A_s$) required. The compressive strength of concrete and the yield strength of steel are 30 N/mm$^2$ and 500 N/mm$^2$, respectively. Use $\alpha_{cc}$ as 0.85.

[5 marks]

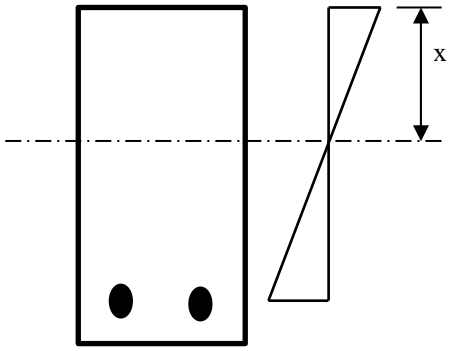



**Figure 1**

2. **Figure 2** shows a ground floor structural plan of a reinforced concrete building. During construction, slabs and beams are cast together. The characteristic strength of concrete, $f_{ck}$ = 30 N/mm$^2$ and characteristic strength of reinforcement, $f_{yk}$ = 500 N/mm$^2$. Based on the information provided, design and provide detailing for slab panel C-D/1-2.

   Given;

   The characteristic actions:

   Permanent load, $g_k$ = 1.5 kN/m$^2$ (Excluding selfweight)

   Variable load, $q_k$ =3.0 kN/m$^2$

   Assume bar diameter = 8 mm

[25 marks]

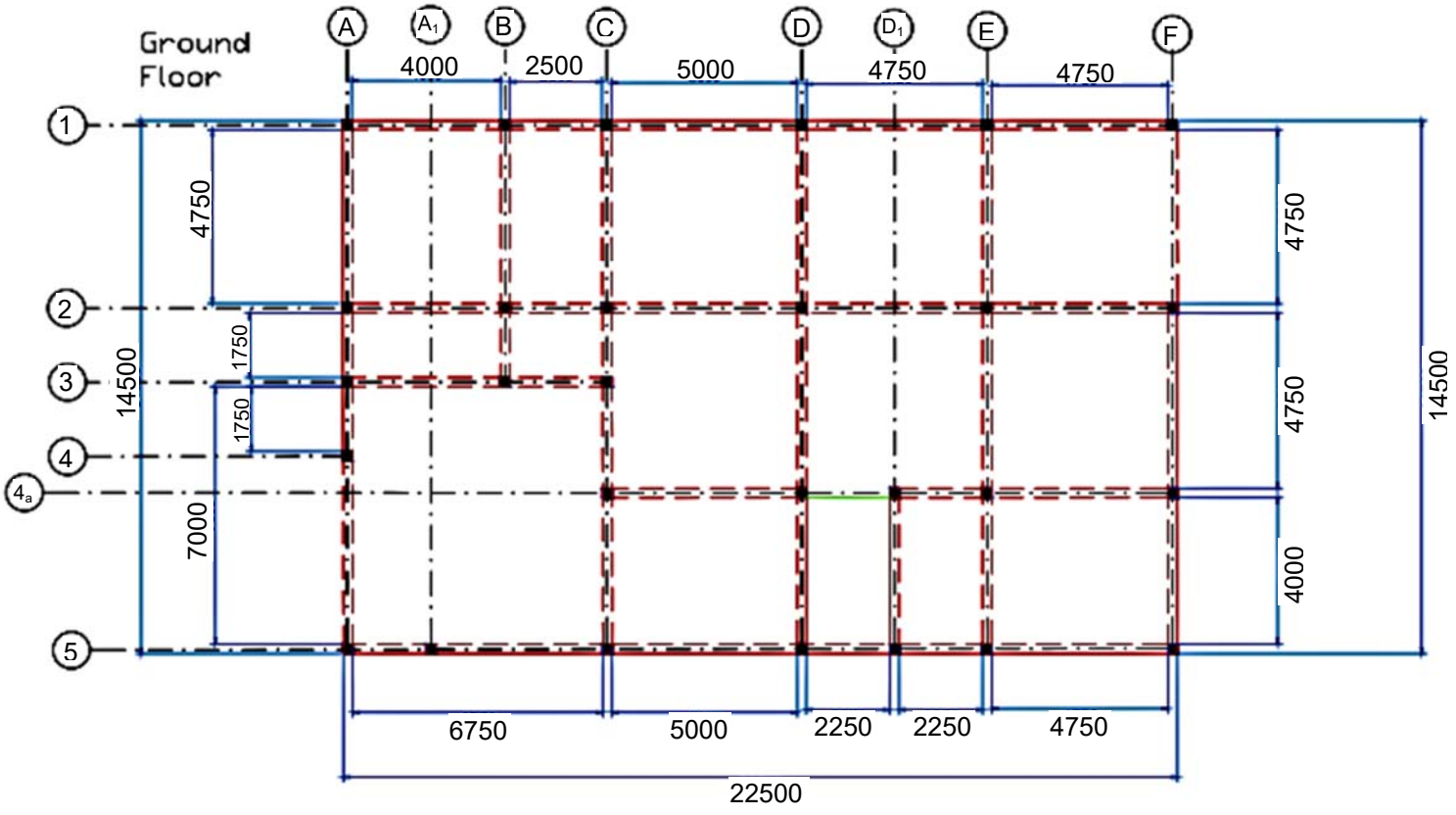



**Figure 2**

**...5/-**

3. **Figure 3** shows the key plan of a roof slab with continuous beam 1/A-D, 2/A-D, 3/A-D and 4/A-D. Given the data below:

| | |
|---|---|
| Variable load | = 3.5 kN/m$^2$ |
| Finishing | = 1.0 kN/m$^2$ |
| Slab thickness | = 125 mm |
| $f_{ck}$ | = 30 N/mm$^2$ |
| $f_{yk}$ | = 500 N/mm$^2$ |
| Density of concrete | = 25 kN/m$^3$ |
| Size of all beam | = 225 × 450 mm |
| Cover | = 25 mm |

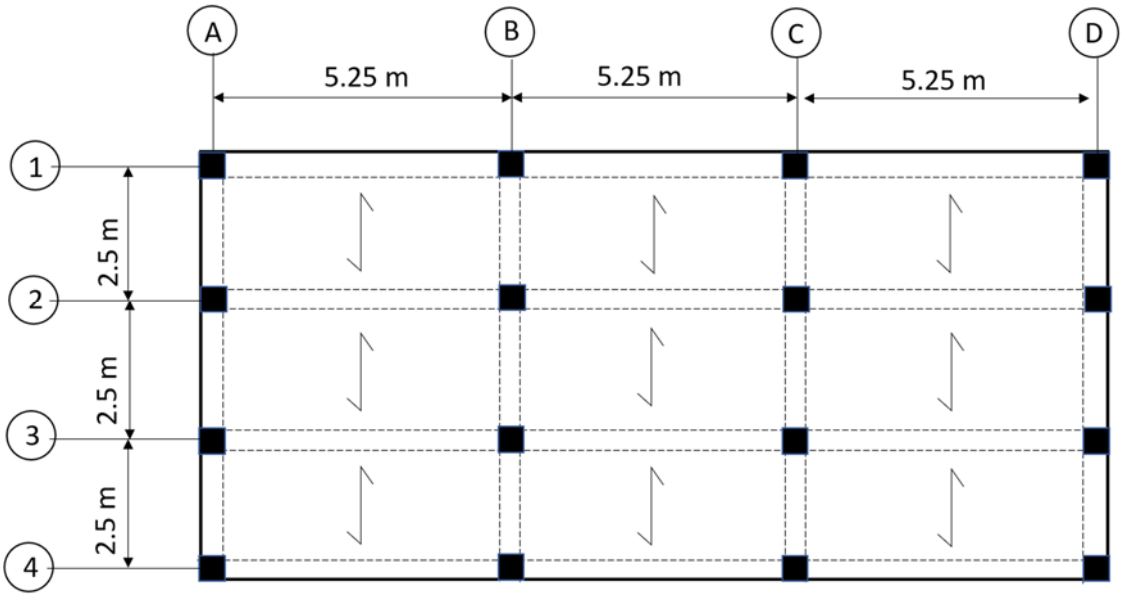



**Figure 3**

For span B-C of the continuous beam 2/A-D,

(a). Design the flexural reinforcement (use rectangular section)

(b). Design the shear reinforcement

(c). Check for deflection

(d). Sketch the detailing

Use the following sizes of reinforcement:

(i). mid-span : H16

(ii). support : H12

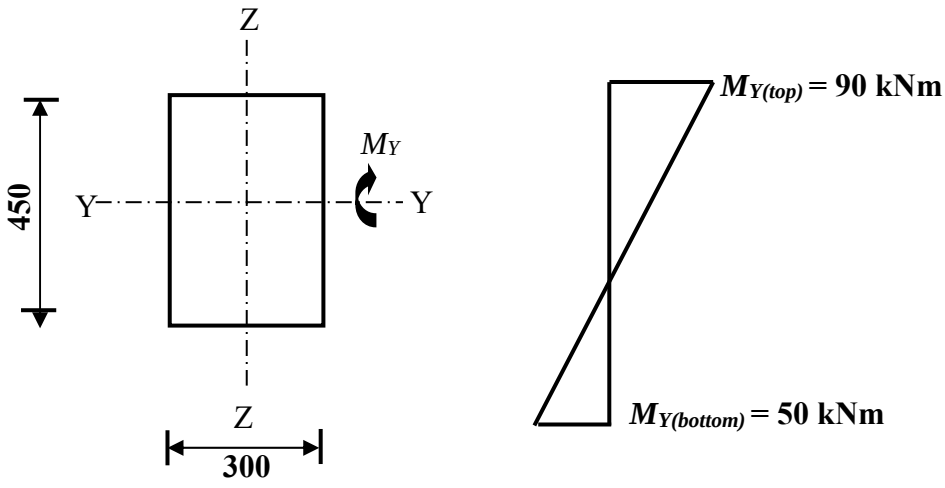
(iii). shear : H10

[25 marks]

**...6/-**

4. (a). A rectangular column subjected to 2000 kN axial load and bending moment about its major axis is shown in **Figure 4**. The column is classified as braced and non-slender. Design and provide the cross-sectional detailing of the column considering concrete compressive strength, $f_{ck}$ = 25 N/mm$^2$, yield strength of reinforcement, $f_{yk}$ = 500 N/mm$^2$, effective length, $l_o$ = 3000 mm and concrete cover = 35 mm. Use H25 mm and H8 mm as the main reinforcement and link, respectively. The design chart is provided in **APPENDIX 1**.

[20 marks]

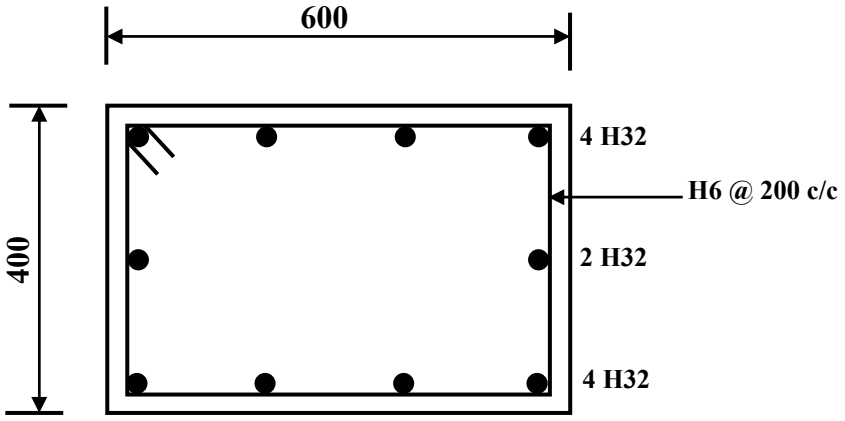



**(all dimensions in mm)**

**Figure 4**

(b). The cross-sectional detail for a 400 mm × 600 mm column at 500 mm above first floor level is shown in **Figure 5**. Based on the design calculation, the column requires 8000 mm$^2$ for the main reinforcement. If the concrete cover is 25 mm, evaluate the detailing of the column, and include relevant sketches..

[5 marks]

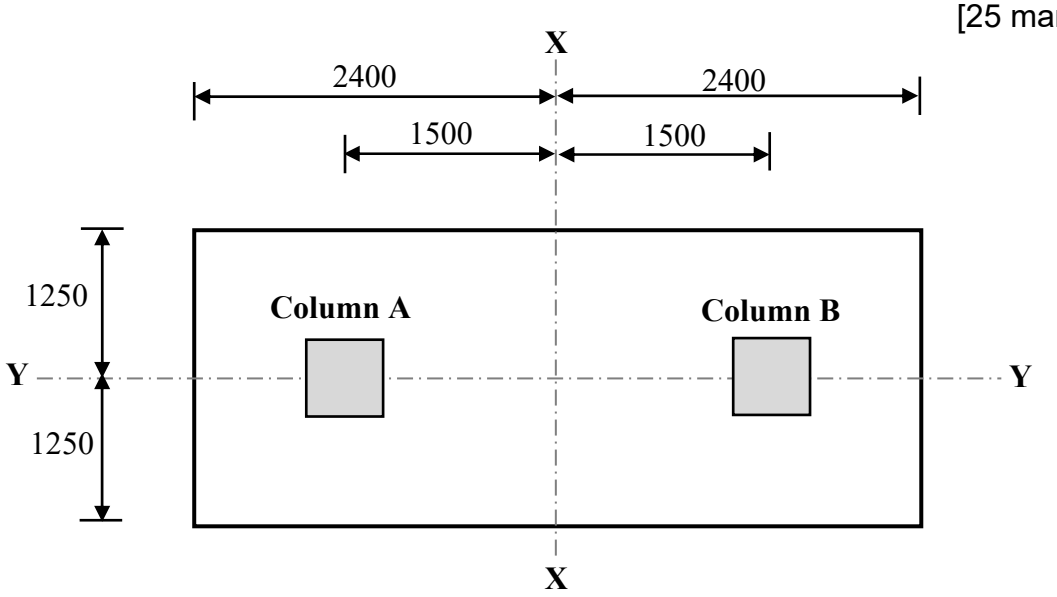



**(all dimensions in mm)**

**Figure 5**

5. **Figure 6** shows the plan, cross-section and the unfactored column load of a combined pad footing that supports two identical columns, namely A and B. If the centroids of the loads and the footing coincide, design and provide full detailing of the footing. Take the concrete compressive strength $f_{ck}$ = 30 N/mm$^2$, yield strength of reinforcement $f_{yk}$= 500 N/mm$^2$, concrete cover = 50 mm, the overall depth of footing = 800 mm and $z$ = 0.95 $d$. The longitudinal and transverse reinforcement shall be 20 mm and 16 mm diameter, respectively. Ignore the shear check at the column face, punching shear, crack control.

[25 marks]




**(a) Plan view**

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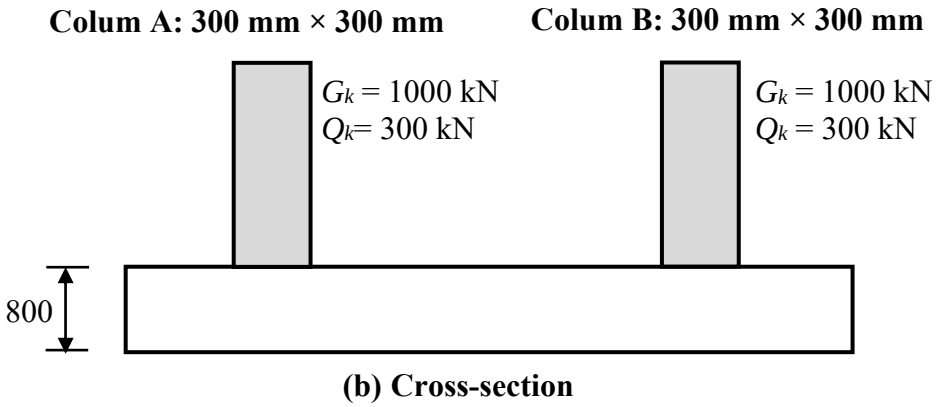
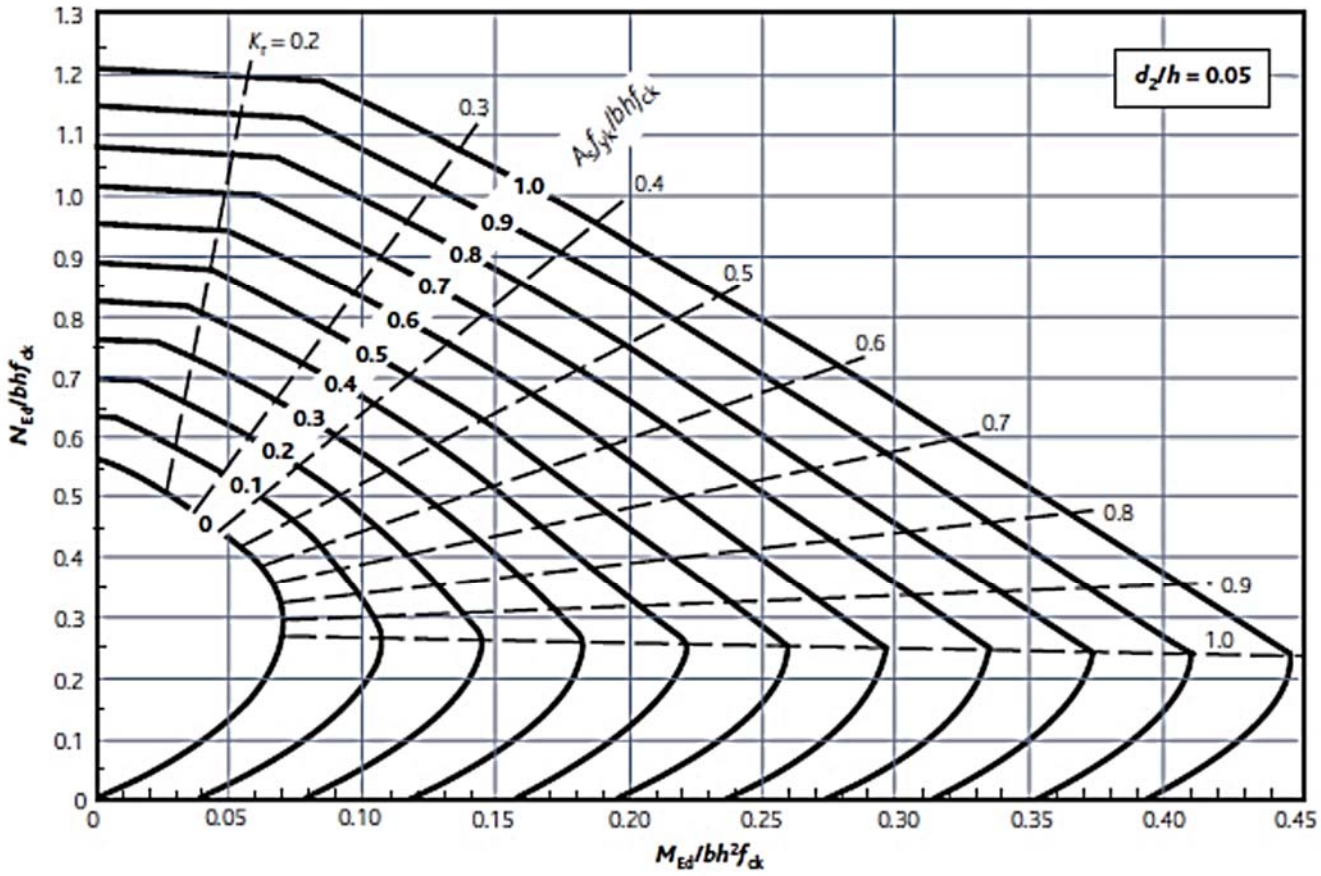



**(b) Cross-section**

**(all dimensions in mm)**

**Figure 6**

**APPENDIX 1**

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